

PHYSICS II: An Outline

Chap 22. Electric Charge

- Charge
- Coulomb's Law

$$\mathbf{F} = k \frac{|q_1||q_2|}{r^2} \hat{\mathbf{r}}$$

Chap 23. Electric Fields

- Electric Field $\mathbf{E} = \frac{\mathbf{F}}{q}$,
 $E = \frac{1}{4\pi\epsilon_0} \frac{|q|}{r^2}$ (point charge),
 $dE = \frac{1}{4\pi\epsilon_0} \frac{dq}{r^2}$
- Field lines
- Electric Dipole $\mathbf{p} = q\mathbf{d}$,
 $\boldsymbol{\tau} = \mathbf{p} \times \mathbf{E}$, $E = \frac{1}{2\pi\epsilon_0} \frac{p}{z^3}$

Chap 24. Gauss' Law

- Electric Flux
 $\Phi_E = \int \mathbf{E} \cdot d\mathbf{A}$
- $\oint \mathbf{E} \cdot d\mathbf{A} = \frac{Q}{\epsilon_0}$
- $E = \frac{\lambda}{2\pi\epsilon_0 r}$ (line charge),
 $E = \frac{\sigma}{2\epsilon_0}$ (sheet of charge)

Chap 25. Electric Potential

- Work $W = -q\Delta V$
- $\Delta U = -\int_a^b \mathbf{F} \cdot d\mathbf{l}$
- $\Delta V = -\int_a^b \mathbf{E} \cdot d\mathbf{l}$, $E_s = -\frac{\partial V}{\partial s}$
- $V = \frac{1}{4\pi\epsilon_0} \frac{q}{r}$ (point charge)
 $V = Ed$ (Uniform Field)
- $dV = \frac{1}{4\pi\epsilon_0} \frac{dq}{r}$

Chap 26. Capacitance

- Capacitance: $q = CV$
- || Plates - $C = \epsilon_0 \frac{A}{d}$
- Series: $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$
- Parallel: $C = C_1 + C_2$
- Energy Stored:
 $U = \frac{1}{2} CV^2$, $u = \frac{1}{2} \epsilon_0 E^2$
- Dielectrics: $K = \frac{E_{vacuum}}{E_{material}}$,
 $C = KC_0$, $\epsilon = K\epsilon_0$

Chap 27. Current and Resistance

- Current: $i = \frac{dq}{dt}$
- Current Density:
 $i = \int \mathbf{J} \cdot d\mathbf{A}$, $\mathbf{J} = nev_d$
- Ohm's Law: $V = iR$,
 $\mathbf{E} = \rho \mathbf{J}$
- Resistivity: $R = \rho \frac{L}{A}$
 $\Delta \rho = \alpha \rho_0 \Delta T$
- Electric Power: $P = iV$

Chap 28. Circuits

- Emf = $\frac{dW}{dq}$
- Series: $R = R_1 + R_2$
- Parallel: $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$
- Terminal Voltage:
 $V = \mathcal{E} - ir$
- Kirchoff's Rules:
 Point, Loop
- RC: $i = \frac{E}{R} e^{-t/\tau}$, $\tau = RC$
 Charging: $q = CE(1 - e^{-t/\tau})$
 Discharging: $q = q_0 e^{-t/\tau}$

Chap 29. Magnetic Fields

- Magnetic Force on
 Current: $\mathbf{F} = i\mathbf{l} \times \mathbf{B}$
 Charge: $\mathbf{F} = q\mathbf{v} \times \mathbf{B}$
- Dipole $\boldsymbol{\tau} = \boldsymbol{\mu} \times \mathbf{B}$, $\boldsymbol{\mu} = Ni\mathbf{A}$
- Crossed fields: Hall Effect
- Circulating charge: $r = \frac{mv}{qB}$

Chap 30. Magnetic Fields Due to Currents

- Ampere's Law:
 $\oint \mathbf{B} \cdot d\mathbf{l} = \mu_0 i$
- Wire: $B = \frac{\mu_0 i}{2\pi r}$
- Loop: $B = \frac{\mu_0 i}{2R}$
- Solenoid: $B = \mu_0 ni$, $n = \frac{N}{L}$
- Biot-Savart:
 $d\mathbf{B} = \frac{\mu_0 i}{4\pi} \frac{d\mathbf{l} \times \hat{\mathbf{r}}}{r^2}$

Chap 31. Induction and Inductance

- Magnetic Flux:
 $\Phi_B = \int \mathbf{B} \cdot d\mathbf{A}$
- Faraday's Law:
 $\mathcal{E} = -N \frac{d\Phi_B}{dt}$
- Moving Conductor:
 $\mathcal{E} = Blv$
- Transformers:
 $\frac{V_s}{V_p} = \frac{N_s}{N_p} = \frac{I_p}{I_s}$
- $\mathcal{E}_{sec} = -M \frac{dI_p}{dt}$,
- $\mathcal{E} = L \frac{dI}{dt}$, $L = \frac{N\Phi}{i}$
- Solenoid: $L = \mu_0 N^2 A/l$
- Stored Energy:
 $U = \frac{1}{2} Li^2$, $u = \frac{1}{2\mu_0} B^2$
- LR: $\tau = L/R$
- LR, LC, LRC Circuits

Chap 32. Maxwell's Equations

- $\Phi_B = \oint \mathbf{B} \cdot d\mathbf{A} = 0$,
 $\oint \mathbf{E} \cdot d\mathbf{A} = \frac{q}{\epsilon_0}$,
 $\oint \mathbf{B} \cdot d\mathbf{s} = \mu_0 \epsilon_0 \frac{d\Phi_E}{dt} + \mu_0 i_{enc}$
 $\oint \mathbf{E} \cdot d\mathbf{s} = -\frac{d\Phi_B}{dt}$

Chap 33. EM Oscillations and Alternating Current

- LC Oscillators:
 $Lq'' + Rq' = 0$,
 $q = Q \cos(\omega t + \phi)$
- RLC Circuits
- $\mathcal{E} = v_0 \sin \omega t$, $\omega = 2\pi f$
 $i = i_0 \sin(\omega t - \phi)$, $V = IZ$,
 $Z = \sqrt{R^2 + (X_L - X_C)^2}$,
 $X_L = \omega L$, $X_C = \frac{1}{\omega C}$,
 $\tan \phi = \frac{X_L - X_C}{R}$
- Power loss = $Vi \cos \phi$
- Resonance:
 $X_L = X_C \Rightarrow \omega_0 = \sqrt{\frac{1}{LC}}$

Chap 34. EM Waves

- $c = \frac{1}{\sqrt{\epsilon_0 \mu_0}}$, $f\lambda = c$,
 $E = cB$
- Energy & Poynting vector:
 $u = \frac{1}{2} \epsilon_0 E^2 + \frac{1}{2\mu_0} B^2$,
 $\mathbf{S} = \frac{1}{\mu_0} \mathbf{E} \times \mathbf{B}$
- Polarization: $I = I_0 \cos^2 \theta$
- Snell's Law, Brewster's angle, Critical angle-below.

Chap 35. Images

- Index of refraction: $c = nv$
- Mirrors: $\theta_i = \theta_r$, $r = 2f$,
 $\frac{1}{p} + \frac{1}{i} = \frac{1}{f}$, $M = \frac{h_i}{h_o} = -\frac{i}{p}$
- Snell's Law:
 $n_1 \sin \theta_1 = n_2 \sin \theta_2$
- Total Internal Reflection:
 $\sin \theta_c = \frac{n_2}{n_1}$
- Refraction at a Spherical Surface:
 $\frac{n_1}{p} + \frac{n_2}{i} = \frac{n_2 - n_1}{r}$
- Apparent Depth
- Lenses:
 $\frac{1}{f} = (n-1) \left(\frac{1}{r_1} - \frac{1}{r_2} \right)$,
 $\frac{1}{p} + \frac{1}{i} = \frac{1}{f}$, $M = \frac{h_i}{h_o} = -\frac{i}{p}$
- Optical Devices: Eye, Telescope, Microscope, Near and far points. $m = \frac{25\text{cm}}{f}$

Chap 36. Interference

- $\lambda_n = \lambda/n$
- Double Slit Constructive
 $d \sin \theta = m\lambda$, $m = 0, 1, 2, \dots$
- Double Slit Destructive
 $d \sin \theta = (m + \frac{1}{2})\lambda$, $m = 0, 1, \dots$
- $I = I_0 (\cos \frac{\phi}{2})^2$, $\phi = \frac{2\pi}{\lambda} d \sin \theta$
- Thin Films $2t = m\lambda_n$,
 $n_2 > n_1 \Rightarrow 180^\circ$ shift

Chap 37. Diffraction

- Single Slit Minima:
 $a \sin \theta = m\lambda$, $m = 1, 2, \dots$
- $I = I_0 \left(\frac{\sin \alpha}{\alpha} \right)^2$,
 $\alpha = \frac{\pi}{\lambda} a \sin \theta$
- Double Slit (ϕ, β above)
 $I = I_0 \left(\frac{\sin \alpha}{\alpha} \right)^2 (\cos \frac{\phi}{2})^2$
- Rayleigh Criterion:
 $\theta = \frac{1.22\lambda}{D}$
- Diffraction Gratings

Chap 38. Relativity

- $\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$
- $\Delta t = \gamma \Delta t_0$, $L = L_0/\gamma$,
 $m = \gamma m_0$, $p = \gamma m_0 v$
- Galilean Transformation
- Lorentz Transformation
 $x' = \gamma(x - vt)$, $y' = y$, $z' = z$,
 $t' = \gamma(t - \frac{vx}{c^2})$
- $u = \frac{u' + v}{1 + vu'/c^2}$
- $KE = mc^2 - m_0c^2$,
 $E^2 = p^2c^2 + m_0^2c^4$

Miscellaneous Constants

- $g = 9.8 \text{ m/s}^2$
 $k = 9.0 \times 10^9 \text{ Nm}^2/\text{C}^2$
 $e = 1.602 \times 10^{-19} \text{ C}$
 $\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2/\text{Nm}^2$
 $1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}$
 $\mu_0 = 4\pi \times 10^{-7} \text{ Tm/A}$
 $c = 3.00 \times 10^8 \text{ m/s}$